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REVIEW OF THE LATEST TECHNOLOGY IN CARTOGRAPHIC DATA ACQUISITION, MANIPULATION, STORAGE AND PRESENTATION, WITH SPECIAL EMPHASIS ON POTENTIAL APPLICATION IN DEVELOPING COUNTRIES: SMALL-SCALE MAPPING, NATIONAL AND REGIONAL ATLASES

Global mapping for the global environment

Paper submitted by Japan**

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1. INTRODUCTION

The growing concern on critical situations of our environment has driven many scientific communities to conduct scientific and technological studies to analyze and solve various phenomena and problems of global environment. The role of the mapping community in this global age does not seem to have been well discussed or defined. Since most information on global environment is related to geographic position on the earth, topographic and thematic maps covering the whole earth with standardized specifications and consistent accuracies (Global Map) would be the most basic and important information infrastructure for global environmental studies.

The objectives of this paper are, therefore,

1) to define Global Mapping as the key role of the present mapping community in this global age, and
2) to propose a new framework of international collaboration for Global Mapping.

2. WHY GLOBAL MAPPING NOW?

Global change, such as global warming, deforestation, desertification and acid rain, is now widely recognized as one of the most important issues imposed on mankind, demanding urgent countermeasures. In order to solve these global problems, it is essential to obtain accurate and up-to-date environmental information of the entire earth and to continue monitoring to detect possible changes of the global environment. Substantial environmental information has been collected mainly through satellite remote sensing. The data stored in the Global Resource Information Database (GRID) created by the United Nations Environment Programme (UNEP) is well-known and widely used for scientific studies through its network. This data actually identified global changes such as desertification and deforestation.

The spatial resolution of this globally available data, however, is as large as 16 km. and does not allow us to take appropriate countermeasures for specific problems of particular locations. Policy makers require at a minimum of one km of spatial resolution, which corresponds to approximately one-millionth scale, for their decision-making processes.

Existing small scale maps of the world are listed in Table 1. Some of these maps at the scale of one-millionth do not have sufficient elevation accuracy, whereas others are outdated, particularly in developing countries. In addition, thematic information such as landuse and vegetation is not mapped at one millionth scale. Consequently, none of these maps satisfies the present needs of global environment studies. The mapping community, therefore, is expected to provide a Global Map immediately.

Maps have been considered as one of the top military secrets in most countries. Since the early 1970's, however, the remote sensing technology has been greatly developed, and commercially available satellite stereo imagery of 10 m pixel resolution has made it possible to make topographic maps at the scale of as large as 1: 100,000 or 1:50,000. Furthermore, the end of the Cold War has greatly diminished the necessity of keeping maps confidential. In other words, there should be fewer political or technical obstacles to accomplish Global Mapping. Rather, in the present world, Global Map should be considered as common property of mankind which is to be maintained regularly to identify significant changes of the earth and its environment, and to record the history of the earth.

Consequently, the mapping community should immediately start to discuss how to implement Global Mapping as one of the most important responsibilities for the international community.

3. PLAN OF GLOBAL MAPPING

The Ministry of Construction of Japan and its affiliate, Geographical Survey Institute, have developed a plan of Global Mapping to be proposed to the international community. The plan is a draft proposal to be further improved through discussions among professionals of mapping community, and should be implemented through close international collaboration.

3.1 GLOBAL MAP SPECIFICATIONS

The plan of Global Mapping is to make maps covering the entire ground surface of the earth at the scale of one millionth both in digital and analog format every five to ten years.

The Global Map should contain the following entities; ground elevation, shorelines, rivers, lakes, marshes, vegetation, deserts, dunes, residential areas (villages, towns, cities), roads, railways, administrative boundaries and geographical names. The Global Map can be used as a general map and also as a base map for delineating other information. It can also be used to extract various types of environmental information and used to develop specific environmental conservation or development projects.

The map scale selection determines the characteristics of the map. For this reason we selected the one millionth scale, as this scale is necessary to represent important ground features in actual shape to grasp environmental conditions. Administrative boundaries of the smallest unit such as villages can also be delineated with noticeable area at the one millionth

scale. This is necessary to plot statistical data on maps for sociological analyses and policy-making.

Another reason is that most fundamental thematic information related to the environment such as geology, soil, and hydrology is available from existing sources at the one millionth scale. Consequently, we can make one millionth thematic maps in the second stage of the Global Mapping. These thematic maps with unified specifications will greatly contribute to the understanding analyses of the global environment.

The one millionth scale is also convenient when plotting grid data on maps as one kilometer on the ground corresponds to one millimeter on the map. The digital data of the Global Map can be used for various numerical simulations. On the other hand, the completion of 1:200,000 or 1:250,000 scale maps of the whole earth requires much more time and cost than that of one millionth. Considering the urgent necessity of unified maps of the whole world, we selected the one millionth scale for Global Mapping.

One may think that new mapping on the millionth scale is unnecessary because there already exist one millionth scale maps covering the entire world such as Operational Navigation Chart (ONC) and World Map by Army Map Service (AMS). But ONC is a thematic map for aeronautical navigation and therefore the representation of ground features does not have enough detail for the one millionth scale. AMS maps are old and have not been revised. Neither of these maps have land cover or vegetation information which is indispensable for environmental studies. Therefore, we believe it is necessary to make new one millionth scale maps for global environment.

3.2 IMPLEMENTATION OF GLOBAL MAPPING

3.2.1 Technical Aspect

Global Mapping is to be accomplished by compiling existing maps and geographic information resources where available. If there are no appropriate maps, satellite imagery will be employed. For example, ground elevation can be measured by using SPOT stereo images. SPOT imagery is also used to delineate detailed ground features such as roads, rivers and urban areas. Other earth observation satellites which acquire stereo imagery can also be used other than SPOT. For land cover interpretation, images of Landsat or other satellites can also be employed. Making maps from satellite imagery has now become a well-established technology, in which most industrialized countries find no difficulty.

Digital cartographic data will be collected by manual or automatic digitization of existing maps or compilation of existing digital data. For the areas where new mapping is required, the direct digital mapping technique will be employed. Geographical names will be collected in cooperation with surveying organizations of each country.

3.2.2 Organizational Aspect

Up to this point mapping has been considered as one of the most important tasks of each country. In addition, the preparation of International Maps of the World on the Millionth Scale (IMW) was recommended by UN Cartographic Conferences, but the preparation itself had to be implemented by each nation. The completion of Global Mapping within a short period of time, however, would be impossible in this manner because many of developing countries have financial and technical difficulties. Global Mapping, therefore, should be done with close international collaboration. There may be a couple of ways to implement Global Mapping. Existing international organizations such as UNEP and United Nations University might be able to launch Global Mapping as a new project with financial support by member countries. Or industrialized countries can bear the responsibility of the mapping task by dividing the whole earth into several blocks. The resulting Global Map data should be distributed through these organization.

Global Mapping task may also be entrusted partly to private surveying companies under contract and partly to national surveying and mapping organizations. By employing existing manpower of each country's surveying organization and bearing the cost of production by international cooperation, the preparation of the Global Map may be conducted in the most effective manner.

APPENDIX --- Mapping with satellite stereo imagery ---

The number of earth observation satellites with the capability of acquiring stereo imagery of the ground is increasing. JERS-1(renamed to FUYOU-1 after launched) was successfully launched in 1992. The OPS sensor loaded in the satellite is a line scan optical sensor with forward and nadir looking sensor arrays producing stereo imagery. SPOT, the first satellite with stereo imaging capability from different orbit paths, has long been used and software applications for stereo plotting of SPOT imagery are already available in the market.

The Ministry of Construction of Japan conducted a study on preparing maps from SPOT imagery from 1987 to 1991 in cooperation with Instituto Geografico Nacional, Peru (Ministry of Construction, 1991) The results of the study are summarized below.

The accuracy of height measurement from SPOT images was about 6 meters in RMS error and about 25 meters in maximum error for flat terrain. For mountainous regions, errors increased to about 10 meters RMSE and about 60 meters maximum. By comparing contour lines with those of existing maps, it was concluded that 40 meter interval contours can be drawn from SPOT stereo data.

The study on image interpretation showed that (1)rivers and shorelines were very clearly visible, (2)roads were sometimes difficult to identify depending on image tone, (3)railways were rather difficult to recognize, and (4)urban areas could be easily distinguished from suburban.

It was concluded that 1:100,000 topographic maps could be made from SPOT images with modified map specifications and supplementary ground surveys.

Considering these results, one millionth scale maps with 100 meter contour interval can be made from satellite imagery with sufficient accuracy if supplemented by other sources of information for linear objects (railways, narrow but important roads) which are sometimes difficult to identify on satellite imagery.

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Table 1 Major Worldwide Maps at present (Geographical Survey Institute, 1991)

Name of the Map	Scale	Organization	Year
General Maps			
Carte generale des continents	1:5,000,000	IGN-France	
Karta Mira	1:2,500,000	USSR and six east European Countries	1964-1975
International Map of the World	1:1,000,000	Each country	1912-
AMS World Map	1:1,000,000	US Army Map Service	1933-1972
Operational Navigation Chart(ONC)	1:1,000,000	US Defense Mapping Agency	1961-
Tactical Pilotage Chart(TPC)	1:500,000	US Defense Mapping Agency	1964-
General Maps (Digital Maps)			
World Data Bank I	1:12,000,000	US Central Intelligence Agency	1966-1967
World Data Bank II	1:1,000,000-1:4,000,000	US Central Intelligence Agency	1973-1977
World Vector Shoreline	1:250,000	US Defense Mapping Agency	-1989
Digital Chart of the World	1:1,000,000	US Defense Mapping Agency	-1992
ETOPO 5		US Geophysical Data Center	
Mundo Carto	1:1,000,000	Petroconsultants	1985-1987
Thematic Maps			
Map of the world distribution of arid regions	1:25,000,000	UNESCO	1977
Desertification map of the world	1:25,000,000	UNEP	1977
Soil Map of the World	1:500,000	FAO & UNESCO	1970-1981
International map of the world vegetation and environmental conditions	1:10,000,000	ICITV	1958-
Potential population supporting capacities of land in the developing world	1:10,700,000	FAO	1982
Physical Environment Maps	1:25,000,000		
Human Environment Maps	1:12,700,000		
Map of the fuelwood situation in the developing provinces of the world	1:20,000,000	FAO	1981
Thematic Maps (Atlases)			
Climate atlas of the world		UNESCO & WMO	
Atlas of world water balance		UNESCO	1977